

0.52; Beta*_{inf}=0.09; R_{beta}=8; A1=0.31; Beta_i (inner)=0.075; Beta_i (outer)=0.0828; TKE(inner)P Prandtl#=1.176; TKE(outer)P Prandtl#=1.0; SDR(inner)P Prandtl#=2; SDR(outer)P Prandtl#=1.168; Energy Prandtl number=0.85; Wall Prandtl number=0.85; Turbulent Schmidt number=0.7.

[0427] Full multi-component diffusion species transport model was chosen. The diffusivity was 1E-5 m²/s. The properties of mixture of A, B, C and D was calculated based on the mass weighted average. The models were run till mass and energy converged to less than 1% of the inlet mass and energy.

Results

[0428] Three points were chosen as shown in FIG. 15. All the points were located on the face of the channel where fluid enters. For each point, a mass-less particle was released and how it moves inside the channel was traced. The amount of time particle spent inside the surface features and the time it spent in main channel, outside the surface features was numerically calculated. Particle 1 and particle 2 never entered the surface feature channel for any Reynolds number.

[0429] The table below compares the time as Reynolds number is increased from 10 to 1000.

TABLE 1

Comparison of particle time spent inside and outside the surface features						
Reynolds number	Particle 1 % Time Spent		Particle 2 % Time Spent		Particle 3 % Time Spent	
	Inside features	Outside feature (inside main channel)	Inside features	Outside feature (inside main channel)	Inside features	Outside feature (inside main channel)
10	0%	100%	0%	100%	28%	72%
100	0%	100%	0%	100%	27%	73%
1000	0%	100%	0%	100%	4%	96%

From the table we can see clearly, that the particle in the corner of the channel enters the surface features. Also when the Reynolds number is approximately 1000, chances of particle to be inside the surface feature decreases considerably compared to when the Reynolds number is 10 or 100.

Example

The Effect of Reynolds Number on the Residence Time Spent in the Surface Feature as a Fraction of the Overall Residence Time for an Active Surface Feature Pattern with More than One Angle Per Feature Along the Channel Width

[0430] A 0.254 m (10") long channel with SFG-0-Cis A/Fanelli type of surface features was considered for the range of Re number from 6 to 600. The simple Chevron type features were mirror images on opposing microchannel faces, in a cis-A configuration relative to the flow. The Chevrons were disconnected at the apex and separated by a distance less than 0.4 mm (or 10% of the total microchannel width). The Fanelli distance or disconnection distance between two legs of a surface feature that are at different

angles is preferably less than 20% of the channel width, and more preferably less than 10% of the microchannel width.

[0431] The width of the main channel is 0.4064 cm (0.16") and the main channel gap is 0.04572 cm (0.018"). The surface features have depth of 0.254 mm (0.01") and width of 0.381 mm (0.015"). The orientation angle is 45 degrees. Over the whole length of this device there are total of 234 surface features on each side of the opposing wall. The nitrogen is fed to the device at different average velocities. The temperature is constant at 25 C. The pressure at the outlet of the device is set at the 1 atm. The Re number is calculated based on the average velocity at the inlet and the hydraulic diameter of the main channel. The flow field is solved by the Fluent CFD modeling tool.

[0432] For the purpose of conducting chemical reactions using the microchannels of feature laden walls, the walls of the flow channels are coated with catalyst. Considering a single surface feature, the ratio of surface area to the fluid volume is quite high. As a result of this, the reactants inside the surface features are more like catalytically converted to the desired products. The time spent inside the surface feature as a fraction of the total residence time can be served as an index for the efficiency of the surface feature

[0433] The residence time of the fluid spent inside the surface features can be calculated as a fraction of the total residence time by integrating along the trajectories of particles introduced from the inlet of the reactor. For practical purpose, a finite number of particles are released and their trajectories are determined. For the geometry of this example two symmetric planes separate the inlet into four equal quarters. Only trajectories of particles released from one quarter of the inlet need to be considered. The quarter is divided into a number of cells. In each cell one particle is released from the center of it. The more cells that are considered, the larger of the ensemble of the particles whose trajectories are traced, and the more detailed residence time results can be obtained by statistical averaging. For the particles released near the wall, they have much shorter diffusion distance to the catalyst loaded wall. They mostly will be converted on the catalytic walls. For the particles released near the symmetric planes, they are not representative in the sense that they might not flow into the surface features at all, especially if the surface features are completely symmetric. The particles released from the gray area are more representative for the purpose of calculating the residence time of the fluid spent inside the surface feature. For simplicity, only one mass-less particle is released from the dark cell at the center and its trajectory traced.

[0434] At any point along the trajectory there is a flow time associated with it which is the real time of the particle spends to arrive that point after its release from the inlet. From the coordinates of any point along the trajectory, it can be determined whether it is inside the recessed space of one of the surface features in the walls. By integrating only the segments of the trajectory which are inside the surface features, the cumulative time of the particle spent in the surface features is calculated. By integrating the whole trajectory from the inlet to the outlet the total residence time is calculated. The ratio of the time the particle spends in the surface features to the total residence time is calculated for all the cases considered and the results are tabulated in the following Table.